

3.2 Application of virtual laboratory benches during laboratory work by future construction specialists

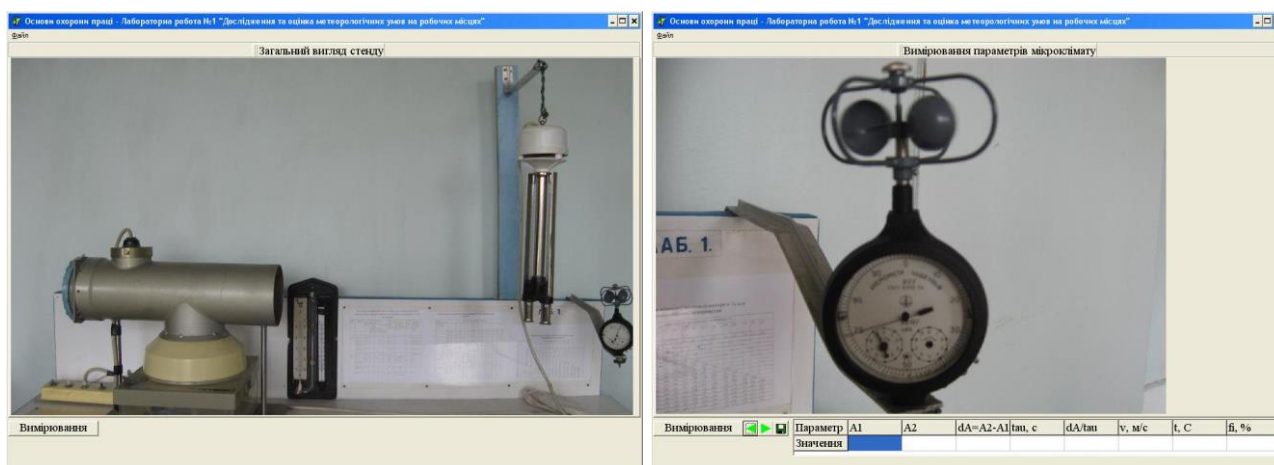
The regulatory discipline "Fundamentals of occupational health and safety" is studied by students of higher educational institutions in order to acquire knowledge, skills and competencies in order to carry out effective professional activities by ensuring optimal management of occupational health and safety at the objects of economic, economic and scientific and educational activities, forming students' responsibility for personal and collective safety and awareness of the need for mandatory full implementation of all measures to guarantee labor safety at workplaces [298-301]. This discipline is also studied during the training of future construction specialists [302-315].

For better assimilation of theoretical material and acquisition of practical skills of discipline "Fundamentals of Occupational Safety", students perform a number of laboratory works in the specified discipline [316, 317], including laboratory work No. 1 "Research and evaluation of meteorological conditions at workplaces". After completing the specified laboratory work, the student should be able to compare experimental measurements of microclimate parameters with normative values and draw a conclusion about the possibility or impossibility of working in such conditions, as well as outline measures and means to bring them to normative parameters [318].

Along with the traditional forms of performing laboratory work on model laboratory stands, the use of virtual laboratory stands on personal computers is becoming more and more widespread to solve the problem of optimization and intensification of training [319, 320]. This approach significantly expands students' access to higher education resources, since the use of virtual technologies in education allows many users to work with the laboratory bench at the same time [319].

In fig. 1 shows the general view of the dialog window of the developed computer program of the virtual laboratory stand "Research and evaluation of meteorological

conditions at workplaces", protected by a certificate of creation (computer program) [321, 322].



a)



b)



c)

Figure 1. General view of dialogue window of developed computer program of virtual laboratory stand for laboratory work "Research and assessment of meteorological conditions at workplaces": a) general view of stand; b) measurement of air movement speed; c) measurement of temperature and relative air humidity

This computer program is characterized by a detailed reproduction in the interface of a virtual stand of the appearance and control elements of a real installation, as well as the implementation of a mathematical model of dependencies between input and output values. The specified laboratory work is also an integral part of the developed distance course on the discipline "Fundamentals of occupational health and safety" [323].

Instructions for using the computer program:

1. Select the "Theoretical information" item from the "File" menu to view the theoretical information on performing laboratory work in a separate window.

2. Turn or close the theoretical information window.
3. Select the "Execution of work" item from the "File" menu. At the same time, the stand is in the initial position.
4. Press the "Measurement" button.
5. Record the initial readings of the anemometer in column A1 of the table (in the program window).
6. Press the ► button. At the same time, the activation of the fan is simulated, the flow of air from which is directed to the cup anemometer and the psychrometer for $\tau=60$ s, after which the fan is turned off.
7. Record the final readings of the anemometer in column A2 of the table, in column $dA=A2-A1$ – the difference between the values of A2 and A1, in column tau – the duration of the experiment $\tau=60$ s, and in column dA/τ – the ratio of the values of dA and tau.
8. Press the ► button to display the tare schedule.
9. Using the calibration graph, determine the air movement speed v by the ratio dA/τ and record it in column v of the table.
10. Press the ► button to display the stationary August psychrometer on the screen, which consists of 2 thermometers – dry and wet, the tank of the latter is wrapped in batiste and moistened with water.
11. Record the readings of dry and wet thermometers in column t of the table.
12. Press the ► button to display the help table.
13. Using the reference table, determine the relative humidity of the air based on the readings of the dry and wet thermometers and record it in column fi of the table.
14. If necessary, you can return to any stage of laboratory work by pressing the ◀ and ► buttons.
15. Save the table of results to a text file for further design of report by clicking the button with the image of a diskette or by selecting the "Save results" menu item.

In fig. 2 shows the general view of dialogue window of developed computer program of the virtual laboratory stand "Research of the efficiency of lighting in industrial premises", protected by a certificate of creation (computer program) [324].

This computer program is characterized by a detailed reproduction in the interface of a virtual stand of the appearance and control elements of a real installation, as well as the implementation of a mathematical model of dependencies between input and output values. This laboratory work is a component of the implemented distance course on the discipline "Fundamentals of occupational health and safety" [323].

After completing the specified laboratory work, the student should be able to compare experimental measurements of natural and artificial lighting parameters with normative values and draw a conclusion about the possibility or impossibility of working in such conditions, as well as outline measures and means to bring them to normative parameters.

Instructions for using the computer program:

1. Select the "Theoretical information" item from the "File" menu to familiarize yourself with the theoretical information regarding the performance of the laboratory work (theoretical information opens in a separate window).

2. Turn on or close the theoretical information window.

3. Select the "Execution of work" item from the "File" menu. After that, an image of the general appearance of the stand will appear.

4. Press the "Start execution" button. After that, the virtual luxmeter is located at a distance of 1 m from the window at a height of the conventional working surface of 0.8 m from the floor level in the horizontal plane.

5. With the help of a virtual luxmeter, take readings of internal lighting for natural side lighting.

6. Record the measured value of illumination in the table.

7. Press the ► button to increase the distance from the window by 1 m.

8. Consistently repeat paragraphs 5-7 for distances from the window of 2, 3, 4, 5 m for natural lighting, as well as for general and combined artificial lighting.

9. If necessary, by pressing the ◀ and ► buttons, you can return to any stage of the laboratory work, as well as extend its performance from any stage.

10. Save the table of results to a text file for further design of the report by clicking the button with the image of a diskette or by selecting the "Save results" item of the "File" menu.

11. Based on the value of external illumination for natural lighting set by the teacher, calculate the coefficient of natural illumination (CNI) for each of the five measured points from the window.

12. Plot a graph of the dependence of CNI on the distance from the window.

13. Choose the lighting standards according to the smallest size of the object of distinction, background and contrast, which are set by the teacher.

14. Compare the measured and normalized values of CNI (at control point 5) and illuminance for general and combined artificial lighting.

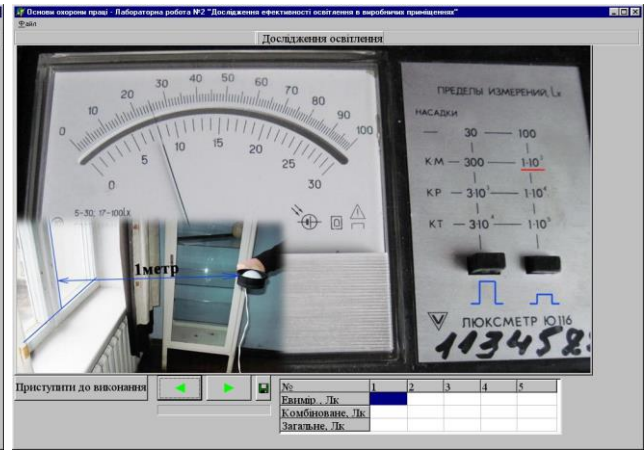
15. To draw conclusions about compliance of the lighting parameters in the room with labor protection standards.

In fig. 3 shows the general view of the dialog window of the proposed computer program of the virtual laboratory stand "Research of industrial noise", protected by a certificate for the work – a computer program [325].

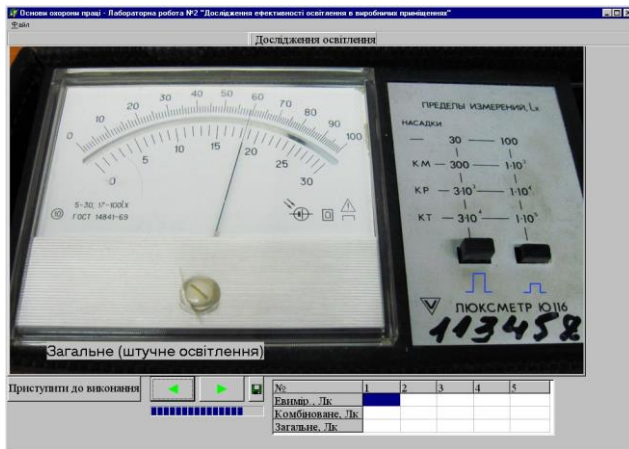
Which is characterized by a detailed reproduction in the graphic interface of the virtual stand of control elements and the appearance of the real installation, use of a mathematical model of dependencies between initial and output physical quantities.



a)



b)



c)



d)

Figure 2. General view of the dialogue window of the developed computer program of the virtual laboratory stand for the laboratory work "Research of the efficiency of lighting in production premises": a) general view of the stand; b) study of natural lighting; c) study of general artificial lighting; d) research of combined artificial lighting

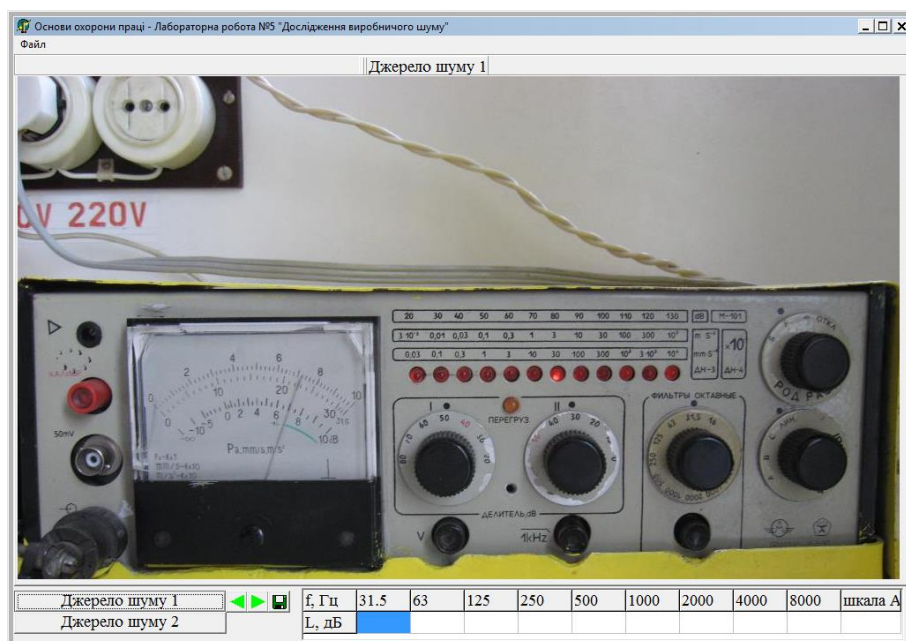


Figure 3. General view of dialogue window of the developed computer program of the virtual laboratory stand for the laboratory work "Investigation of industrial noise"

This laboratory work is also a component of the implemented distance course on the discipline "Fundamentals of occupational health and safety" [323].

During the performance of the indicated laboratory work, the student should familiarize himself with the physical characteristics of noise, its normalization and measurement, learn how to compose noise from several sources, and investigate the effectiveness of noise protection with soundproofing barriers.

Instructions for using the computer program of the virtual laboratory stand "Research of industrial noise":

1. Select the "Theoretical information" item from the "File" menu to familiarize yourself with the theoretical information regarding the performance of the laboratory work (theoretical information opens in a separate window).
2. Turn or close the theoretical information window.
3. Select the "Execution of work" item from the "File" menu. After that, an image of the general appearance of the stand will appear.
4. Press the "Noise source 1" button.
5. For noise source 1 (NS1), measure the sound level (in dB) in an octave band with a geometric mean frequency of 31.5 Hz.

6. Record the measured sound level from DSh1 in the table.

7. Press the ► button to switch NS1 to the next octave band.

8. Consistently repeat paragraphs 5-7 for octave bands with geometric mean frequencies of 63, 125, 250, 500, 1000, 2000, 4000, 8000 Hz, as well as taking into account the "A" correction of the sound level meter.

9. If necessary, by pressing the ◀ and ► buttons, you can return to any stage of the laboratory work, as well as extend its performance from any stage.

10. Save the table of results to a text file for further design of the report by clicking the  button or selecting the "Save results" item from the "File" menu.

11. Press the button "Noise source 2" (NS2).

12. Carry out measurements, record and save the results for NS2 similarly to NS1 according to paragraphs 5-10.

13. Calculate analytically the sound levels and sound pressure levels created by NS1 and NS2 working simultaneously.

Learning with the help of virtual laboratory stands harmoniously fits into modern pedagogical concepts, allows you to use class time more rationally, to conduct laboratory classes not only in subject classrooms.

Before starting the laboratory work of the "Fundamentals of Occupational Safety" discipline, future construction specialists pass a test of their knowledge level using a computer program described in detail in works [326-329].

Thus, learning with the help of virtual laboratory stands, computer test verification and assessment of students' knowledge is a new, progressive method that creates optimal conditions for learning and testing students' knowledge, in particular during the training of future construction specialists, and deserves its wide application implementation in the educational process, bringing our country closer to entering the system of higher education of the world and European community.